

Design and Fabrication of Automatic Wall Plastering Machine Prototype

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Abstract: The building construction is one of the most unfamiliar R&D activities in the robotics and automation community. Nevertheless, the building construction is one of the oldest and largest economic sectors. Intense competition, shortages of skilled labor, increase in labour cost and technological advances are forcing rapid change in the building construction. Building construction is divided into two large groups: commercial infrastructure and residential building. Both areas are needed plastering work for increasing the quality of construction. Machines has been developed to automate the plastering work is very much demand for construction field. It includes microcontroller, relay, AC/DC motor, fabricated structure, display, belt drives etc. The present work highlights the design and developments of prototype in this area and also a new model is proposed to automate the plastering work. Initially the model was developed and fabricated for considering the normal constructed brick wall. The completed model was validated by testing the machine using the brick wall and the statistical details of the manual work are also observed at the different conditions.

Keywords: AC/DC motor, Display, Fabricated structure, Masonry Leveling Compound (MLC), Microcontroller, Relay

I. Introduction

Now a day's construction revolution has made the contractors to equip their construction in such a way so as to perform the highest output with as minimum construction cost as possible. In order to have highest output the parameters like accuracy, precision, quality and cycle time have to be optimised, this optimisation is possible either by having a skilled man power or automating the system. In the first case, continuously doing the same kind of work for long time will cause fatigue resulting in lower efficiency. So it would be better to automate the system if work nature if of same is in case of large construction. With the automation it is also possible to have higher efficiency, accuracy and quality. Contractors are also concerned with safety levels of the worker as well; automation also provides a solution on the safety aspects of both worker and machine.

With the constant increase in the demand of the construction, the contractors are forced to increase their construction and also the quality of the construction to remain in the competitive market. The construction industry in most countries amounts to 10–20% of the GNP [1], making it the largest economic employing sector. It is still labor demand and also most of the work involved is repetitive. The growth of any country is dependent on the construction industry hence it is of prime economic significance to many industrial sectors. Intense competition, shortages of skilled labor and technological advances are forcing rapid change in the construction industry, thus encouraging its automation in this industry.

The construction of buildings, apartment, complex, shops, homes are basic requirements of human being. In this construction area plastering is necessary for decorating the wall. Plastering works refers to construction or ornamentation done with plaster [2], such as a layer of plaster on an interior wall or plaster decorative moldings on ceilings or walls. This is also called plastering. The process of creating plasterwork called plastering. Tools and materials include trowels, floats, hammers, screeds, a hawk, scratching tools, utility knives, laths, lath nails, lime, sand, plaster of Paris, a variety of cements, and various ingredients to form color washes.

Plasterers will typically divide a room, (especially a large or high-ceilinged wall) into top and bottom. The one working on top will do from the ceiling's edge to about belly height and work off a milk crate for an 8-foot (2.4 m) ceiling, or work off stilts for 12-foot-high rooms. For cathedral ceilings or very high walls, staging is set up and one works topside, the others further below.

1.1 Plastering technic

Figure 1 shows the trowel operation technic in traditional plastering method. The correct plastering technique is essential with only the trowel being used to apply and finish the skim coat. Achieving a good finish is the combination of firm pressure combined with the correct angle of trowel (how far the leading edge is from the wall). Plastering Technique for applying plaster is initiated by trowel loaded with plaster, and then leading edge of the trowel will be a long way from the wall. The leading edge need to be flattened gradually into the

wall. With the next stroke the trowel will be used for flattening out the plaster as just applied. There will be no plaster on trowel and it will be fairly flat - the leading edge will be approximately 10 – 15 mm away from the wall.

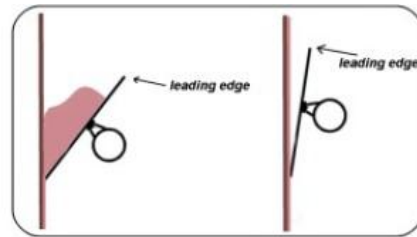


Fig.1 Trowel operation technique.

Firm pressure will push the plaster flat and even. The pressure applied through the trowel is to be considered for the evenness and angle is maintained as required. If the leading edges is more than 15 mm away from the wall then the trowel will start to scrape plaster off the wall. Close this angle down so that it is 10 - 15 mm away and can push hardy and it will give a nice clean even, hollow free application. This plastering technique is crucial to maintain good consistence at all times. With the correct method speed will then increase very quickly.

The stages of plastering is applying the plaster and smoothing out immediately there are many situations that can only be resolved in the stages. It is also not a case of just moving from one stage to the next. Progression through the stages is determined by how quickly the plaster starts to firm up. Move from one stage to the next once the plaster has firmed up and gone tacky.

If at any stage do not see any improvement then this does not necessarily mean there is anything wrong with plastering technique but probably that the plaster is too wet. In the early stages the objective is flatness not smoothness. The smoothness will come later, but only if achieved flatness so, always remember the objective of each stage. The setting process of plaster can firm up for two different reasons either, due to the natural setting process or due the moisture being sucked out of the plaster by the backing coat. The single most important aspect to be aware of is suction. If don't have it under control then no matter how good plastering technique will never be able to achieve a good finish. The suction test should always be carried out. If applied skim coat on plasterboard then it need not problem as the suction is controlled. In some instances if the backing coat is very porous the moisture can be sucked out almost instantly. This is clearly not good as by the time to have finished applying plaster to the whole wall, the first application will be totally dry.

1.2 Different aspects

This specification is for the application of Specialized Construction Products fiber reinforced Masonry Leveling Compound (MLC) and finishing system. MLC is a pre blended, cement-based plaster that can be easily applied as a single leveling/flanking coat over a variety of masonry backgrounds to produce a high quality even and true surface. The specially developed plaster mix contains a blended mix of aggregates, cement, proprietary ingredients and a unique fiber reinforcement which allows for easy application as a thin leveling coat for concrete block, brick walls and masonry surfaces. The fiber reinforcement MLC contains not only relieves curing stresses but also provides an excellent surface key for a variety of conventional plaster finishes.

1.3 Pre-plastering requirements

The masonry/brick substrate must be installed in strict accordance with the manufacturer's specifications and recommended installation procedures. All pointing shall be flush finished. The manufacturers required curing time must be allowed after placement of the bricks to ensure all of the pointing has completely cured and the walls have stabilized. Failing to allow the pointing to fully cure can lead to excess shrinkage and cracking on the pointing lines after the walls have been plastered [4]. The finished appearance of the wall is highly dependent on the standard of the wall construction. Plastering cannot commence until; all the surfaces that are to be coated are level. There must be no more than a 3mm deviation in the surface alignment over a 1200mm radius. All the necessary waterproofing elements must have been completed and checked and the joinery must be in place.

All junctions between the masonry/brick substrate and dissimilar materials must be correctly flashed and sealed with MS Silaflex or another approved equivalent. The MS sealant must be installed in strict accordance with the manufacturer's requirements and must be left to properly cure prior to plastering. Construction Joints must be provided according to the brick manufacturers design criteria. All construction joints must be in place and must be waterproof prior to the commencement of plastering.

Technical trends in construction automation

As observed, the robots and systems for building construction were mostly developed in the mid-1980s and early 1990s and experienced severe economy lasting from the mid-1990s up to date. Many robots dropped off from the fields during which period due to economic reasons. This means that the currently used systems and robots, such as concrete floor finishing robots, steel structure welding robots, etc., proved their advantage and managed to survive the economic hardship. Further, improvements are expected to be made in those systems and robots so that they will expand their applications in the future.

On the other hand, new types of robots are being developed for the emerging social needs, such as the measures against aging workers, increase of renewal works of old buildings and the rising concerns on environmental issues.

The construction sector employs 83 per cent casual workers and hence, is similar to the Indian workforce demographic. It also represents a large majority of the workforce as it is the second largest employer after agriculture. The details about the employment are as shown in the Fig 2.

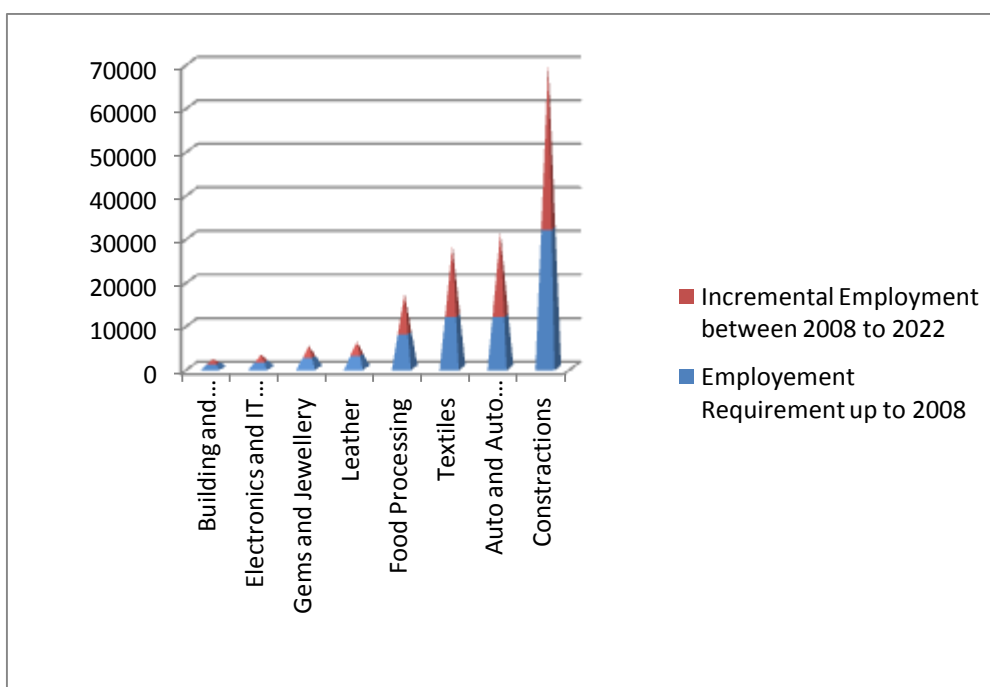


Fig. 2 Labour requirement during 2008 to 2022 in different industries

(Source: NSDC, XIth Five Year Plan by the Planning Commission, Government of India)

1.4 Shortage of skilled construction workars

The Indian construction industry comprising infrastructure and real estate sectors employ over 26 million casual workers and are the country’s second largest employer after agriculture. The Planning Commission of India has projected that the construction sector will require another 47 million people in the workforce over the next decade (FICCI 2010:13) [5]. Despite such significance to the Indian economy, there is no specific policy for skill building in the construction sector. Table 1 shows the current pool of the construction workforce in India comprises mainly unskilled workers.

Table I Current employment details in different industries

Category	Percentage of Employment	Total Employment
Unskilled workers	83%	25.6 million
Skilled workers	10%	3.3 million
Engineers	3%	0.8 million
Technicians and Foremen	2%	0.6 million
Clerical	2%	0.7million

Source: Report of Working Group on Construction for the Eleventh Five year Plan, Planning Commission, Government of India

Most of these unskilled workers are seasonal, migrant workers from poorer agricultural states and they lack education and formal training and usually pick up skills on the job, informally from peers or supervisors, resulting in an inefficient performance on the job. Among the 10 per cent skilled construction workers,

emigration to overseas countries - Gulf countries in most cases - for higher wages is common. Emigration worsens the shortage of skilled workers and creates an upward pressure on domestic wages leading to a situation where Indian firms have to import workers to meet their requirements.

The Ministry of Labour and Employment has also documented that “violation of laws on minimum wages, equal wages, child labour, contract workers and interstate migrant workers etc., is rampant in construction as in agriculture and home based occupations” (Government of India 2011c:635).

Realizing the severity of the shortage of skilled construction workers, the government of India had conducted a skills mapping study and identified carpentry, electrician, painter, welder, masonry, crane operations and plumbing as key roles which will be in demand until 2022 and the level of skills required as shown in Table 2.2. Together, these key roles will require 7.3 million vocationally trained workers by 2022.

Table II Demand Of Different Labour In The Construction Industry Until 2022

Profile	Incremental Requirement ('000)	Skill Level
Project Manager and Engineers	473	Specialized
Supervisors	473	Specialized
Surveyors	47	Specialized
Foremen	946	Specialized
Crane Operators	7	Vocationally Trained
Electricians	473	Vocationally Trained
Welders	473	Vocationally Trained
Plumbers	1183	Vocationally Trained
Carpenters	1892	Vocationally Trained
Others(including painters, Equipment Operators)	459	Vocationally Trained
Steel fixers	1419	Vocationally Trained
Masons	1419	Vocationally Trained
Minimally educated	38083	
Total	47302	

Source: Report on human Resource and skill building Requirements in the Building, Construction and Real Estate Service, National Skill Development Corporation

The Indian construction industry complained of a shortage of skilled workers which is likely to worsen if more workers are not made employable or processes are replaced with the corresponding equipment, however the extent to which the labour is going to get shorter in future that, it is not only required to manufacture construction equipment but also there is a need to automate the equipment to avoid the labor shortage to run these equipment, Following paragraph explains about the patent information of the construction equipment in related to the automation in plastering.

II. Objective

From the discussion it can be concluded that there will be a shortage of labour in the future in the construction industry by this the labour cost is going to rise, hence there is a need for automating the construction processes. Some of the processes are automated by developing machines like concrete pouring machines, plastering machine for automating the residential construction process. But the masonry work which is an important and major process in a construction process still being manually done. As the plastering work is the major part of the any construction of the building it has to be automated immediately before the industry reach labour shortage phase without compromising the quality of work and also the productivity, Hence the work proposes a model to automate the plastering work and the objectives of the present work are as follows. The main objective of this project helps in providing an effective solution to construction applications by using microcontroller operated motor drive for making necessary activity.

III. Fabricated Components

The structures are fabricated by using required necessary components like steel frame, sheet metal, metal bars, power screw, AC/DC motors, different wheels nut and bolts. All these are well assembled as for the requirement. This will be controlled by controller through control components.

IV. Control Components

The microcontroller is families to use on-chip flash memory for program storage, as opposed to One-Time Programmable ROM, EPROM, or EEPROM used by other microcontrollers at the time [6]. Low power, high performance microcontrollers handle demanding 8 and 16-bit applications. With a single cycle instruction RISC CPU and a rich feature set, the architecture ensures fast code execution combined with the lowest possible power consumption. Whether program in C or assembly, the tuned instructions decrease program size and development time. The well-defined I/O structure limits the need for external components and reduces

development cost. A variety of internal oscillators, timers, UARTs, SPIs, Pulse Width Modulation, pull-up resistors, ADCs, Analog Comparators and Watch-Dog Timers are some of the features available for creative applications.

This is design for the projects having electronics, embedded system, robotics and industrial-automation. This board is made in such a way that it becomes easier for anybody to learn about micro controllers. This board can also be used in various applications and projects.

This board includes Atmel's ATmega8 Microcontroller with 8kb flash memory working at 16MIPS, LCD interface, Motor Driver for connecting DC motors or Stepper motors, servo interface, regulated power supply, PC interface through UART, Buzzer. 12 MHz external crystal, Exposed all 21 I/O pins, Exposed 7 channel I/O pins for ADC, Exposed 12 I/O channels for sensors and other peripherals with 5V/1A power supply, Exposed 8 channel I/O pins for servo, sensors and other peripherals with dual power supply. Four tact switches for external input and reset. Four test surface mounted LEDs for status and debugging purpose. Two supply indicator LEDs. Dual power supply through DC source (6V to 16V) or USB powered, USB programmer. Dual or single power supply option, ISP pins for programming. Option for connect or disconnect LEDs Option for separate AREF (Analog Reference) for ADC. Option for separate AVCC (Analog VCC) for ADC.

V. Working Of The Machine

The machine consists of a metal frame, sheet metal tray supported by M.S angular, guide ways, thickness adjuster or pressurizer and motor. Initially, the plastering machine has to be placed near the wall which has going to plaster. The machine should be perfectly leveled. Then the cement mixture which consists of cement and sand in the ratio approximately around 1:4 is poured into hopper of the tray. The lifting force is transferred to tray through power screw, which driven by AC motor.

The lifting force is given by a belt and pulley mechanism. The linear movement to the tray assembly is given through a guide way. The main part is fixed to vertical column of metal frame and another part of guide way is fixed to tray setup. Using pressurizer setup, this consists of four bar link mechanism. Applying pressure or vary the thickness of plaster is done with these power screws. This activity is controlled by using microcontroller.

VI. Quality And Wastage

The thickness of the mortar into the wall achieved by the labour was varying from 0.5 inches to 0.75 inches at different wall condition. But the machine is achieving any thickness constantly and uniformly. It is observed that the wastage is reduced by 0%. Whereas mortar thickness at the wall is increased wastage is also increased by the labour and it is also depends on the skill of labour.

VII. Conclusion And Scope For Future Work

7.1 Conclusion

The present work includes applying the mortar into the wall and also pressuring mortar with a making surface level. The model has been developed and tested successfully. With this development the two major problem construction industries currently facing can be reduced. They are skilled labor shortage and Quality in the construction process with less wastage. Through the trials it is noted that the machine is more productive compare to the labour with respect to the plastering work and also the quality achieved is almost equivalent to the labour.

7.2 Scope for a Future Work

The present model is semi-automatic and it does not have an automatic loading of mortar. The automation of loading mortar has needed to be carried out. The machine is developed to do plastering work for straight wall, hence it is suitable only for commercial buildings like apartment which has large in size and not for the construction of a curved wall as it does not have to make curved blade. Hence upgrading is required by making some changes to use the machine for any size and for the corners and joining of two walls.

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